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CORBA Object Request Broker Survey for the ECS Project

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1. Introduction

1.1 Purpose

The purpose of this White Paper is to provide a survey of the Object Request Broker (ORB) technologies and associated development environments that are commercially available and to relate their current offerings to submissions to OMG for next-generation products. A prototype, utilizing the current OMG Object Management Architecture (OMA), including a CORBA-compliant ORB is being considered by CSMS. One or more of these products may selected prototyping portions of the ECS architecture.

1.2 Organization

This paper is organized as follows:

- Section 2 provides a general overview of the principal components of the Object Management Group's OMA (Object Management Architecture), with particular focus on the ORB environment and associated standards.
- Section 3 identifies and provides an overview of several ORB products and related products.
- Section 4 provides a brief discussion of topic related to the current and future ORB environment, which are referenced in the discussion of the individual ORB products, to complete the survey of ORB and ORB-related COTS products.

1.3 Review and Approval

This White Paper is an informal document approved at the Office Manager level. It does not require formal Government review or approval; however, it is submitted with the intent that review and comments will be forthcoming.

The ideas expressed in this White Paper are valid as a snapshot of a technology and associated technologies at a point that coincides with the original release of this white paper.

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2. Distributed Object Computing (DOC)

As has been presented in the DCE Migration and Prototype Study and the DME Migration Study, object-oriented computing is the strategic goal of major operating system and system/network management vendors. Much of the industry is focused on delivering next-generation products for a Distributed Object Computing environment. This widespread industry movement to common distributed object-oriented models acknowledges that the industry realizes that computing environments of the future will not only be object-oriented but highly heterogeneous in nature. This fact underlies much of the industry support for this model. This has two important ramifications. First, vendors will be focusing on delivering products that can support a highly heterogeneous environment, such as is represented in the ECS environment. Secondly, it is also indicative that more emphasis will be placed on environments, such as DCE and DFS, that provide "glue" to integrate these diverse heterogeneous environments into the Enterprise. Objects Request Brokers will be another primary component of the "glue" that will be used to bind diverse technical environments in the future.

2.1 Computing Models

The term "Client/Server" is a broad definition that may be appropriately applied to a broad range of implementations. The term client/server can be used to describe a traditional Client/Server model or a Distributed Object Computing model. In a traditional client/server model, either the client or the server, possibly both, must be able to identify the other's location, often through the use of some type of directory service. The traditional client/server model does not specify or preclude an object-oriented design.

The Distributed Object Computing (DOC) model provides advanced features ideally suited to highly distributed, heterogeneous environments. The Object Request Broker (ORB) is the principal communications mechanism of the DOC model. The ORB supports three capabilities that are not supported in traditional client/server models:

- The DOC ORB finds and **initiates** the server (object implementation in the DOC model) for any client request. Traditional client/server locates but does not initiate the server.
- The DOC model supports dynamic invocation of services, including those that may not have been present when the ORB application was originally created. Traditional client/server only supports a static interface.
- The DOC model supports dynamic allocation and de-allocation of services, making more efficient use of system resources. This dynamic capability is not supported by traditional client/server implementations.
- The DOC model typically will reflect an object-oriented design which supports reuse, and will also support one or more methods to encapsulate legacy code. The DOC model supports reuse at a much higher level than traditional client/server implementations. Traditional client/server does not support encapsulation.

The focus of the current CSMS architecture is the Distributed Object Computing (DOC) model. This document will provide a brief overview of industry trends related to the DOC model and a discussion of the leading Object Request Brokers and associated development environments currently available as COTS products.

2.2 OMG's Object Management Architecture

The full Object Management Group (OMG) object model, the Object Management Architecture (OMA), is composed of several component architectures. CORBA is one of the principal architectural components of OMA. Object Services and Common Facilities are also major architectural components of the OMA.

Although the focus of this survey is commercially available, CORBA-compliant ORB products, these products should not be viewed in isolation from other major components of the OMG OMA object model. CORBA is sometimes irreverently referred to as the "object plumbing" of the DOC model. While distributed "object plumbing" is certainly critical, other specifications are evolving to provide the "doors and windows" as one OMG official recently phrased it. Therefore, before beginning the discussion on the OMG CORBA architecture, commercially available ORBs, and associated products that support these environments, the supporting and complementary roles of OMG's Object Services and Common Facilities components will be briefly noted in regard to the overall OMA model.

2.2.1 OMG's Common Object Services Specification

Some analysts consider that the Object Services, which are comprised of a fundamental set of system service interfaces in support of the ORB, should be given the same or greater consideration than the ORB implementation. The Common Object Services Specifications (COSS) was accepted by OMG in August 1993. This submission, led by SunSoft, was joined by 20 other vendors, including the following vendors:

AT&T/NCR	BNR Europe Ltd.
Digital Equipment Company	Groupe Bull
Hewlett-Packard	HyperDesk Corporation
ICL PLC	IBM
Itasca Systems, Inc.	Novell, Inc.
O2 TECHNOLOGY	Object Design, Inc.
Ontos, Inc.	Oracle Corporation
Persistence Software	Servio Corporation
Teknekron Software Systems, Inc.	Tivoli Systems, Inc.
Versant Object Technology Corporation	

The OMG COSS specification covers the three services that many consider the most fundamental object services, the basic services on which other services depend. These include the following:

- Naming
- Event Notification
- Life Cycle

The Naming Services provides the ability to attach textual names (like those provided by X.500, DCE CDS or ONC NIS+) to object references. The OMG Naming Service is based on Federated Naming to provide directory services transparently across various directory service implementations. The Event Notification Services provides notification of unexpected events (e.g., telecommunications, alarms, etc.). The Life Cycle Service defines services and conventions for creating, deleting, copying, and moving objects.

Recently SunSoft and IBM combined their submissions on the more complex Persistence Service. This proposal was submitted and accepted by OMG. This acceptance completed the first of the RFPs that OMG has laid out in its Roadmap to define the object services that may be needed to support an ORB implementation. The OMG Object Services Roadmap is presented in Table 2-1.

Table 2-1. OMG Object Services Roadmap

RFP #	Projected Completion Dates	Object Services to be Addressed	Status
RFP #1	8/93	Lifecycle	Accepted 8/93
	8/93	Naming	Accepted 8/93
	8/93	Event Notification	Accepted 8/93
	8/93	Persistence	Accepted 12/93
RFP #2	2/94	Security	Final selection stage
	2/94	Relationships	Final selection stage
	2/94	Transactions	Final selection stage
	2/94	Concurrency Control	Final selection stage
RFP #3	12/94	Externalization	RFP issued
	12/94	Data Interchange	RFP issued
	12/94	Licensing	RFP issued
	12/94	Trading	RFP issued
RFP #4	12/94	Query	RFP issued
	12/94	Change Management	RFP issued
	12/94	Properties	RFP issued

These object services may be grouped in the following functional categories:

- Services to locate objects:

  Naming Service

Trading Service

- Services that are utilized in the storage of objects:

  Persistence

  Externalization

  Concurrency

  Transaction

  Query

  Data Interchange

- Utility Services:

  Security

  Events

  Associations

  Properties

  LifeCycle

2.2.2 OMG Common Facilities

OMG has established the Common Facilities Task Force to evaluate and select a compound document architecture and other facilities used regularly by desktop applications for inclusion in the OMA model. Microsoft's OLE, CIL's OpenDoc specification and Lotus's LEL are the primary candidates for inclusion. Microsoft's OLE and CIL's OpenDoc are the considered to be the front-runners: Microsoft OLE because of its current installed base and OpenDoc because of its vendor/platform/GUI neutrality, network-aware implementation and strong multi-vendor support. Both OLE and OpenDoc are discussed in more detail in section 4.2 (Microsoft's OLE) and 4.3 (OpenDoc) because of the relationship of this technology to Enterprise-level Object Model implementations and the apparent confusion of some in the industry over the role of these object models. The OMG OMA model will support and provide full integration of desktop-level objects, such as compound document component. Under the OMA Common Facilities architecture, the selected desktop compound document architecture will be compatible with the other OMA components, including CORBA and Object Services.

2.2.3 CORBA, a Distributed Object Computing Architecture

The Common Object Request Broker Architecture (CORBA) from the Object Management Group (OMG) is the most widely supported ORB architecture. There has rarely been such solid industry-wide support for a standard with this level of Enterprise-wide impact.

The focus of this overview will therefore concentrate on CORBA-compliant ORBs which are the focus of the principal potential hardware and POSIX-compliant operating systems vendors for the ECS Project. Although the most current version of the OMG Common Object Request Broker Architecture (CORBA) standard is 1.2, there are very minor differences between versions

1.1 and 1.2. Version 1.2 focused mainly on syntactical clean-up and other document composition revisions of the original 1.1 specifications. The industry generally refers to the standard as 1.1 and this paper, except for this notation, will observe this convention. All discussed ORBs have implemented all CORBA 1.1 features unless otherwise noted. Only similar implementations of CORBA 1.1 (often from one vendor) will interoperate. Toolkits and development environments for these ORBs are available, although these range from basic compiler support to fully integrated development environments. Most of these environments support general application development utilizing the vendor's ORB implementation. A few are targeted, at least in part, to a systems and/or network management environment, including those from Tivoli, ICL and Netlabs/DAC/Synoptics partnership utilizing the DG SMAP ORB. The various ORB implementations support a variety of transports, including DCE, ONC+, IPX, TCP/IP, Sockets and CMIP. It should be noted the CORBA 2.0 specifications are related exclusively to inter-ORB communications and that the developer environment for CORBA 1.1 is fully defined. The selected CORBA 2.0 interoperability mechanisms are expected to be transparent to the application level code and therefore will not affect developed application-level code.

Interoperability between different ORB implementations is not guaranteed by CORBA 1.1. Interoperability between ORB implementations is being addressed by an OMG RFP (CORBA 2.0). Proposals were to address **Interoperability and Initializations** between different ORB implementations. Submissions related to this RFP, including extensions to several ORBs discussed in this overview, have been made by individual vendors and by vendor consortia. The OMG will make a technology selection over the next few months and develop the specifications for CORBA 2.0. The vendor community and consortia, such as OSF (which currently includes the former COSE consortia members), are very much committed to addressing this issue. OMG will ensure interoperable ORBs through the competitive solicitation process and specification recommendation process.

The ORBs discussed in this white paper are presented in their current implementation, compliant with current CORBA 1.1 specifications. It should be noted that some vendors have added features and extensions proposed as CORBA 2.0 specifications, while others are waiting for the final OMG specifications for CORBA 2.0. ECS may select one of the presented ORBs in its current version for near-term prototyping and proof-of-concept implementation, but product advances are expected with the finalization of CORBA 2.0. Finalization of the CORBA 2.0 specifications is expected to initiate rapid development and availability of a wide spectrum of products targeted toward this nearly universally accepted model. The OMG selection of the CORBA 2.0 model specifications may effect both the desirability and the availability of specific ORB implementations as compliant CORBA 2.0 implementations.

Although thirteen vendors issued a letter of intent to submit a proposal to OMG for the CORBA 2.0 interoperability and initialization specifications, only six submissions were delivered. Table 2-2 provides an overview of vendors making CORBA 2.0 submissions, as well as the original CORBA 1.1 submissions. As can be seen in this table, most CORBA 2.0 proposals center around the mechanisms supporting interoperability between ORBs. These schemes may be generally classified into one of following categories, although there are variations within both categories.

- Support for interoperability mechanisms that support direct interoperability between homogenous ORB implementations without the use of a gateway or other required translation facility. Gateways would be used only when the ORB implementations could not interoperate directly.
- Support for an interoperability mechanism that would require a gateway for **any** inter-ORB communications, even when the ORB implementations were capable of interoperating without a gateway.

Table 2-2. OMG CORBA 2.0 Submission

Submission	Associated Vendors and ORBs	Submission Highlights	Intent to Submit to CORBA 2.0 RFP	Final 2.0 Submission March 1994	Original CORBA 1.1 Submissions
OSF Joint Submission	OSF[1], HP[2], DEC[3], HyperDesk[4], NEC	Proposes a mechanism to by-pass gateway when communication is between homogeneous ORB implementations.			(except NEC, OSF)
IBM	SOM/DSOM	Generally considered similar to OSF Joint submission, as regards transport issues, but includes proposal to support specific IBM SOM/DSOM implementation characteristics.			
SunSoft /IONA	DOE ORB	Proposes a gateway mechanism for all inter-ORB communication.			
Expersoft	XShell	Proposes a gateway variation utilizing an EOR (Exportable Object Reference) to facilitate all inter-ORB communication.			
ICL	Dais-based ORB	Proposes standardization of Object Services for greater transparent interoperability between ORB implementations without gateways.			
BNR Europe (Northern Telecom Subsidiary)	BNR ORB	Proposes gateways[5] as protocol translators between ORB implementations; a common RPC mechanism for all ORBs and inclusion of a Trader Service (ISO RM ODP standard).			
AT&T Global Information Solutions (NCR)	Cooperative Frameworks-based ORB	Issued Letter of intent to submit proposal, but withdrew before final submission.			(as NCR)

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1 No specific ORB, but underlying transport mapping support for DCE, as well as ONC+ and IPX.

2 HP provides the DOMF ORB technology, as well as Distributed SmallTalk and the DCE-integrated ORB Plus environments..

3 DEC provides the ObjectBroker ORB, COHESIONworX, and a gateway to Microsoft's COM compound object model, based on Microsoft's OLE.

4 HyperDesk provides the DOMS or HD-DOMS ORB.

5 The BNR proposal defines a gateway as "An object which logically resides in two or more ORB domains and is responsible for mapping operation invocations between the domains."

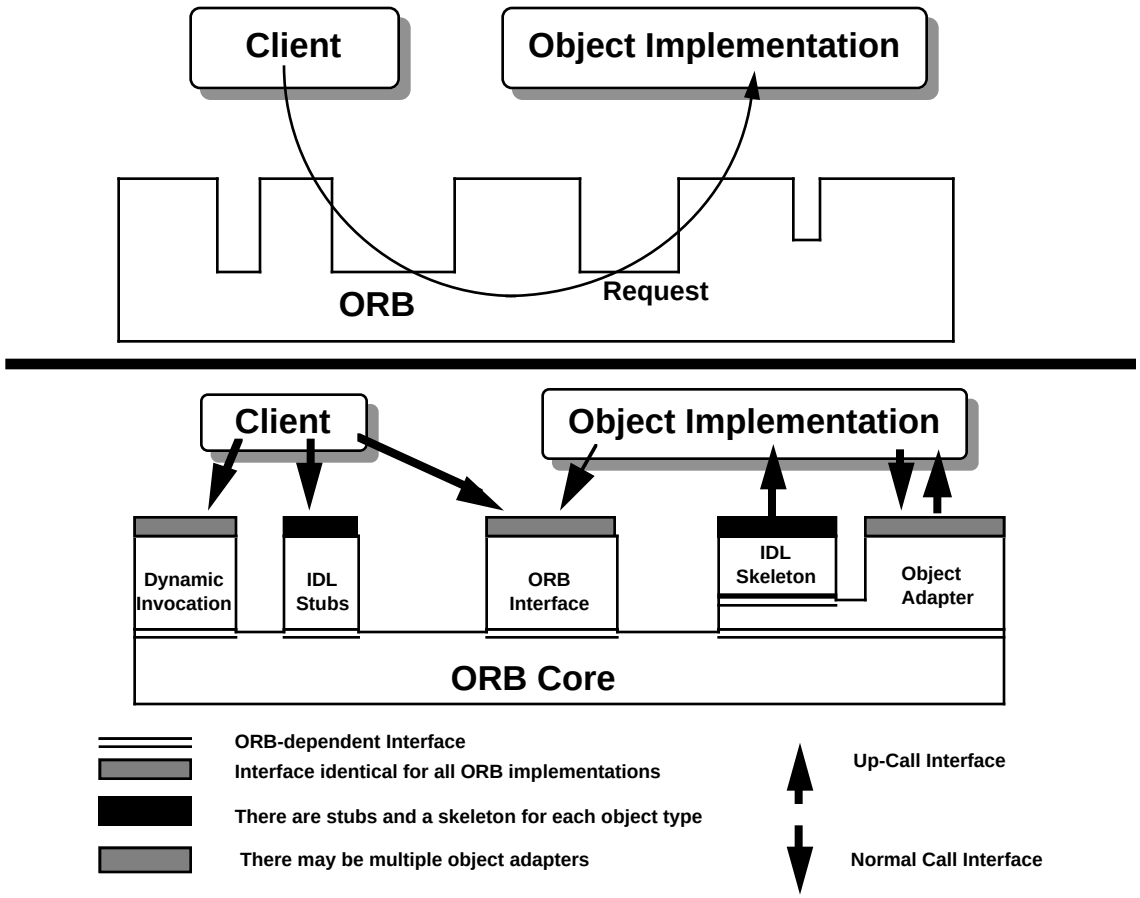
2.3 The Object Request Broker

2.3.1 Function of the ORB

The principal function of the Object Request Broker (ORB) is to manage object interactions across a network or in memory. Clients make requests for data or services. These requests are passed to the ORB which locates the requested object or service. The ORB will also return any response/result to the client object. In effect, the ORB provides what is missing in distributed computing middleware to make the network a fully distributed operating system.

Figure 2-1 illustrates the communication mechanisms of a typical ORB. The top drawing in this figure illustrates the flow of a client request through the Object Request Broker to the Object Implementation which will provide the data, service, etc. The bottom drawing in this figure illustrates the structure of CORBA-specified Object Request Broker interfaces, which are capable of supporting a variety of application types and technical environments.

Figure 2-1. ORB Communication Mechanisms[6]



2.3.2 ORB Transport Services Implementations

CORBA 1.1 does not specify the underlying transport services implementation. However, consistent services, such as naming, are expected to be provided by the specific implementation. Implementations which use the same transport mechanism, such as DCE naming and RPCs, greatly facilitate interoperability, e.g., HP's ORB Plus environment uses DCE CDS (Cell Directory Service) as a "locator object" used by the client to locate the object implementation. Interoperability between ORBs utilizing the same transport services, will of course require less manipulation and perhaps costs (i.e., gateways may be needed, requiring additional processing power) than those utilizing multiple transports, which may require gateways.

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[6] Source: The Common Object Request Broker: Architecture and Specification; Revision 1.1

3. COTS ORB Products

The several CORBA-compliant (version 1.1) ORBs are presented in this section, including SunSoft's DOE (Distributed Object Everywhere), DEC's ObjectBroker, HP's DOMF (Distributed Object Management Facility), HyperDesk DOMS (Distributed Object Management System), IBM SOM (System Object Model), IONA's Orbix, Expersoft's XShell, Cogent's ORB*lite*, Tivoli's TME-based ORB, ICL's Dais-based ORB, AT&T's Cooperative Frameworks-based ORB, and a DG SMAP ORB environment. The announced supported platforms and vendor toolkits are included with a brief description of the current supported platforms. Most of the ORB development environments mentioned include class libraries supporting the environment.

Other vendors, including Symbiotics, a LAN Network products vendor, and BNR (Bell Northern Research, a European Northern Telecom subsidiary), have been active in CORBA 2.0 OMG activities. These vendors use ORBs within their environments, and are obviously interested in the evolution of the CORBA specification. The vendors do not have commercially available implementations, which include development environments, and are therefore not included in following listing, although they are referenced elsewhere in this White Paper.

Public Domain toolkits, third-party commercial toolkits, and COTS class libraries are also becoming available for this technology on many platforms/environments. The third-party toolkits and class libraries of which we are currently aware are included below, but a search of all available CORBA-compliant toolkits and available class libraries has not yet been conducted. The absence of a third party toolkit herein therefore does not necessarily indicate either strength or lack of support for a specific environment at this time.

3.1 SunSoft DOE/IONA Orbix

SunSoft's Project DOE (Distributed Objects Everywhere) is based on a CORBA-compliant ORB from IONA Technologies. SunSoft and IONA have jointly submitted a response to the OMG CORBA 2.0 RFP. The SunSoft/IONA ORB implementation is based on SunSoft's ONC+ transport mechanism. SunSoft was one the six original contributors to the CORBA 1.1 specifications.

Although SunSoft has submitted an alternate proposal to OMG, supporting an inter-ORB gateway implementation. Sun has been active with IBM and HP in cross-licensing and supporting portions of the SOM and the DOMF object models. The goal of all three vendors was to assure interoperability between ORBs. These vendor-specific alliances took place over the past year and the technologies are incorporated into the three vendors ORB implementation currently. In addition, Sun is a member of X/Open, OMG and has recently joined OSF. Interoperability between not only the ORBs, but the underlying transports, is one of the main goals stated in the original COSE announcement.

Sun has also formed an alliance with NeXT and plans to integrate NeXT's NextStep object technologies within its CORBA-based DOE object model, calling the environment OpenStep. NeXT has indicated that it will license Sun's ORB and comply with the CORBA specifications.

Oberon Software has announced that its Synchroworks Development Tools, in its next release, will provide support for Sun's DOE environment. Sun has stated its intention to port its DOE environment to other platforms, but no specific platform has been announced. IONA's Orbix is available on several platforms and is discussed separately in this context in section 3.6.

3.2 DEC's ObjectBroker

DEC was one of the six original contributors to the CORBA 1.1 specifications. DEC's CORBA-compliant ObjectBroker, like the other ORBs discussed in this study, is intended to support cross-platform communication. The ObjectBroker is based on a DCE transport mechanism. DEC joined with OSF, HP, NEC and HyperDesk in a submission to OMG for CORBA 2.0.

DEC's ObjectBroker, currently in version 2.5, can support integration with the following environments: OpenVMS, DEC OSF/1, Ultrix, SunOS, IBM AIX, HP-UX, Microsoft Windows, Macintosh and Windows NT. These environments can be supported either because of a native ObjectBroker ORB, a "bridge" to the COM (discussed below) architecture supporting OLE, or an interoperable ORB based on DCE (HP-UX, AIX).

The ObjectBroker is supported by Digital's IPDMA (Integrated Product Development Management Architecture) tools and by the COHESIONworX development environment. The ObjectBroker and COHESIONworX development environment are currently available for SunOS and DEC OSF/1. C++ is the programming language supported by COHESIONworX.

Microsoft is the only major vendor that has not agreed to support the CORBA specifications directly. DEC has also provided a COM (Component Object Model) interface to integrate the Microsoft OLE Model with the DCE-based, CORBA-compliant ObjectBroker. Once this gateway-managed translation has taken place, the Microsoft OLE object can communicate with other DCE-based, CORBA-compliant objects. Portions of OLE have been integrated into DEC's ObjectBroker. As a result, interoperability can be supported between the two environments, which is important since many installations desire transparent communications across all platforms, including Microsoft PCs supporting OLE. If an interoperability mechanism were not provided, there would be additional isolation between UNIX and PC installations with an Enterprise.

It should be noted that in its present form, OLE is better described as a compound document architecture than a full Object Model, such as OMG's full Object Model Architecture (OMA), of which CORBA is a part. This topic is briefly addressed in sections 4.2 and 4.3.

3.3 HP's DOMF

HP was one of the six original contributors to the CORBA 1.1 specifications. IBM and Sun have licensed DOMF technologies and HP has licensed IBM SOM and Sun DOE technology. HP, as

a COSE (now OSF) member, is also committed to ORB and transport interoperability with other COSE vendors, including those utilizing transport mechanisms other than DCE.

HP currently provides an integrated development environment for the CORBA-compliant DOMF ORB environment called Distributed SmallTalk, based on ParcPlace Systems VisualWorks development environment. SmallTalk is the supported development language. Distributed SmallTalk is supported on HP 9000 series 700 and 800 running HP-UX, IBM RS-6000 running AIX and Sun SPARCstations running SunOS and Solaris. HP claims Distributed SmallTalk is 100% portable across supported platforms.

HP has also developed the ORB Plus environment, which will support CORBA 1.1 and will be integrated with DCE. C++ is the development language supported. ORB Plus is in beta on the HP-UX platform.

HP will also support Taligent object technologies. Taligent is an object-oriented operating environment funded by IBM and Apple. HP has recently purchased a minority stake (15%) in Taligent. As part of the agreement, Taligent has agreed to integrate components of HP's DOMF, including HP's ORB into the Taligent environment. Taligent will also integrate DCE into its environment. Taligent, of course, also supports IBM's SOM/DSOM object technology components as well as the OpenDoc compound document architecture, which is composed largely of technologies from Apple and IBM (refer to section 4.3 for additional discussion of the OpenDoc compound document architecture). As an additional part of this strategy with HP, Taligent intends to work with X/Open Company Ltd. to submit for standardization its Application Programming Interfaces (APIs) for the portable Taligent Application Environment (TAE) as an open industry specification. In addition, Taligent will support the OMG CORBA specification for distributed object computing and increase its participation in the OMG's standards efforts. Pre-release Software Development Kits (SDKs) for the Apple and OS/2 environments are expected to be released this summer (1994). The TAE environment is expect to be commercially available in mid-1995 on other platforms.

3.4 HyperDesk DOMS

HyperDesk of Westborough, Massachusetts was one of the contributors to OMG for the original CORBA 1.1 specifications. HyperDesk also released the first CORBA-compliant ORB in January, 1992. Novell purchase a 10% share of HyperDesk in early 1993, with the intent of using the CORBA-compliant DOMS as its object architecture and the basis of the AppWare Development Environment. HD-DOMS is also supported on other platforms, including Sun and Microsoft Windows. HyperDesk was also part of the joint submission to the OMG RFP for CORBA 2.0. This joint submission included OSF, HP, DEC, and NEC. HD-DOMS utilized the native operating system/network services as its transport mechanism and provided interoperability with other platforms using HD-DOMS.

It has been recently announced (March 14, 1994) that HyperDesk is withdrawing as an ORB provider. Novell has reported that they are in discussion with HyperDesk to take control of the technology. It is expected that the recent Novell software vendor acquisitions, Serius and Rational, and other vendors developing under the AppWare environment will support the DOMS CORBA-compliant ORB that Novell appears to be in the process of acquiring from HyperDesk.

3.5 IBM SOM

IBM's SOM (System Object Model) has been extended to include distributed object models and is referred to as DSOM (Distributed System Object Model) in this context. It is compliant with CORBA 1.1. SOM and DSOM have implemented OSF DCE as the underlying transport mechanism. Although it is not generally considered to be radically different than the joint OSF submission, IBM has submitted a separate ORB interoperability proposal to OMG for CORBA 2.0, based more specifically to support characteristics of its SOM/DSOM implementation.

IBM's SOM 2 ToolKit supports both the SOM and DSOM environments. It has been available since August 1993 for stand-alone workgroups on OS/2 and AIX. IBM intends to provide both the ORB and toolkits for all its supported operating systems, including OS/2, Workplace Shell, AIX, AS/400 and MVS in 1994. The SOM environment is intended to be platform and language independent (C, C++ and SmallTalk are currently supported). Independent development tool vendors, including Neuron Data, ParcPlace Systems, Inc., Digitalk, Inc., Metaware Inc., Watcom International, and Objective Inc. have also announced support for SOM in upcoming releases.

IBM has also recently announced that its SOMobjects toolkit for Microsoft Windows will provide the capability for Microsoft OLE-based applications to use SOMobjects and interoperate with them, using a technique IBM terms a COM "emitter". Refer to sections 4.2 and 4.3 for additional information on COM and OLE. IBM's CORBA-compliant SOM is also the object model used in the OpenDoc compound document architecture.

3.6 IONA's Orbix

Some of the technologies in the IONA ORB were developed during work on the European ESPIRIT project. Orbix supports compliance to CORBA 1.1. As indicated above, Orbix is the ORB used in SunSoft's DOE architecture. The Orbix architecture supports a modular communications layer and reportedly can support other transport mechanisms such as DCE, in addition to ONC+, but not both at the same time. SunSoft owns a minority stake in IONA.

The IONA Orbix is currently supported on SunOS, Solaris, Silicon Graphics IRIX, HP-UX, and Windows NT, with imminent releases planned for SCO and OS/2. Orbix provides basic compiler support for these platforms, often supporting the native compiler. Orbix currently internetworks across Windows NT and Solaris. C++ is the primary programming language supported. A more extensive development environment for the ORBIX ORB has not been identified at this time, on platforms other than SunSoft.

3.7 Expersoft's XShell

Expersoft's XShell is a CORBA 1.1-compliant ORB supported on a variety of platforms, including SunOS, HP-UX, SGI Irix, SCO UNIX, AIX and NextStep, supporting application development tools and C++ compilers from SunPro, Lucid and Centerline. XShell, version 3.0 due this month, will support a distributed daemon architecture and distributes an application's naming and management services across the network.

Expersoft submitted a response to OMG's CORBA 2.0 RFP, proposing its architecture which would allow each communicating ORB a choice of transport mechanisms, such as DCE, ONC+, etc. Expersoft is proposing a mechanism called an Exportable Object Reference (EOR), which would encapsulate the EOR into a proxy object that would be client-opaque and ORB-specific.

3.8 Cogent's ORB*lite*

ORB*lite* consists of a compiler for OMG's Interface Definition Language (IDL) and an Object Request Broker. The Cogent ORB uses TCP/IP as its transport mechanism. ORB*lite* can support concurrent application without threads, but works more effectively in a threads environment. C++ is the supported programming language.

ORB*lite* does not currently support all CORBA 1.1 specifications, including the following: C language mapping; interface and implementation repositories; Dynamic Invocation Interface; Type `any`; Basic Object Adapter (BOA) functions for creation, activation; and deactivation of implementations, although they will be supported in future releases.

As stated in the vendor literature "ORBlite is intended to be useful for developers that need a rapid prototyping capability or who do not want to create a dependency on such heavyweight network computing environments as DCE or ONC+". The availability of CORBA-compliant ORBs for TCP/IP environments is a positive sign for serving a diverse user community.

3.9 Tivoli's TME-based ORB

Tivoli developed one of the first commercially available ORBs, which was first released in 1991, as the CORBA 1.1 specifications were being finalized. This original Tivoli environment was not CORBA-compliant, having been developed before the CORBA specifications were finalized. The Tivoli Management Environment (TME) has been brought to CORBA-compliance (1.1). Tivoli provides the ADE application development environment. Tivoli has submitted API technology, which is supported in the ADE development environment to both OMG and X/Open. The X/Open proposals are now being considered, with adoption likely as one of the X/Open Management APIs.

The TME-based ORB was used in Unix-International's Distributed Manager before Unix International was disbanded in late 1993. Several Systems Management vendors, such as Legent, use the TME-based ORB and its associated development framework as an integration mechanism for their systems management applications. Sybase is teaming with Tivoli for managing distributed databases.

The TME is available on several platforms, including Solaris, HP-UX and AIX. TME has announced ports to NT. TME is targeted at a systems management application development environment rather than at more general purpose end-user application development as supported by most other ORBs in this study.

3.10 ICL's Dais-based ORB

The ICL Dais environment, which also includes a CORBA-compliant ORB, supports the European ANSA (Advanced Networked Systems Architecture) standard, which formed the basis of OSF technologies. The Dais ORB is not available as a separate ORB environment, but is supported within the overall Dais environment. ICL submitted a response to the OMG RFP for CORBA 2.0.

ICL proposes that translation of messages to canonical representations and transmission over a standard protocol should **not** be required for local or homogeneous environments. The ICL response focuses on transparency concerns between ORB implementations, especially supporting "mechanisms to interact meaningfully" between functionally-rich ORBs (those that can support security and transaction management) and those that do not support the same functional levels.

3.11 AT&T Cooperative Frameworks-based ORB

AT&T Global Information Solutions is the new name of NCR, a subsidiary acquired by AT&T in 1991. AT&T Global Information Solutions recently joined the reorganized OSF. The Cooperative Frameworks, the primary development environment of AT&T Global Information Solutions, provides a CORBA-compliant ORB, as well as related tools and services. C++ is the supported programming language. The full Cooperative Frameworks environment will include a developers library of more than 300 C++ classes for building the foundations of ORB-based distributed applications.

The Cooperative Frameworks environment is available on System V Unix, with plans to make the environment available on UnixWare and NT.

AT&T Global Information Solutions, which originally planned to submit a CORBA 2.0 proposal, but withdrew in favor of one of the 6 final submissions, which has not been identified.

3.12 Data General's SMAP ORB

The Data General SMAP ORB is being used as the basis for development of an innovative management architecture in a venture which includes NetLabs, Digital Analysis Corporation (DAC), and Synoptics Communications Corporation. The SMAP ORB implementation uses CMIP as the message transport for objects. The products are intended to function as a self-standing architecture or as extension products to other management platforms such as HP's OpenView. Several products are commercially available. This implementation is of course targeted at integrated systems and network management applications, rather than general application development.

3.13 Other CORBA-compliant tools

3.13.1 X-Consortium CORBA-compliant C++ Toolkit

The X Consortium is due to formally release the most recent version of X-Windows, X11/R6, in the middle of this month (April, 1994). Several features have been informally announced,

including an advanced C++ toolkit, named Fresco, which will support the interface description language (IDL) as defined by the OMG for CORBA 1.1. It is expected that Fresco will become a public domain application like the X-Window product. Using Fresco, an object can theoretically be a distributed object in the OMG sense. This will support capabilities to embed objects within objects, which will be the same regardless of whether the objects are local or remote. Bob Scheiffer, original creator of the X Windows System, also indicated that Fresco will also provide rich facilities for creating structured graphics and structured text. Additional information is expected with the formal announcement. A year or more is usually needed for the X-Window releases to become available in commercial products.

3.13.2 Oberon Software

Oberon Software, in Cambridge MA, has announced that SynchroWorks visual programming environment, version 2.0, with expected availability in late 1994, will support OMG's CORBA standard and IDL (interface definition language) specification. The environment supports access to Oracle, Sybase and Informix databases. It is currently only available on SPARC platforms, supporting Sun's DOE environment, but is expected to be announced as available on the HP-UX environment in this quarter (2nd-94). C++ is the supported programming language.

3.13.3 NextStep PDO Toolkit

NeXT will be providing the NextStep Portable Distributed Objects (PDO) toolkit to allow NextStep systems to initiate programs on another system. NeXT has indicated that the PDO conforms to CORBA and will support DCE. PDO will be available on HP and Data General platforms. A port is planned to the DEC Alpha platform running OSF/1. SunSoft has licensed the technology for Solaris, called OpenStep on this platform, supporting ONC+, as is discussed above in the SunSoft DOE section.

3.13.4 ParcPlace Systems

In addition, to being remarketed by HP for the Distributed Smalltalk environment (refer to HP DOMF above), ParcPlace has announced that its VisualWorks development environment will support IBM's SOM and Sun's DOE on their respective platforms. DEC is reported to be planning a port of VisualWorks to the Alpha AXP running Digital's OSF/1 and Windows NT.

3.13.5 OpenVision

OpenVision has announced support for DEC's CORBA-compliant ObjectBroker and will port the DEMAX product line, which was acquired last year to the DEC distributed object environment. The vendor stated that CORBA-compliance and the potential for interoperability with other CORBA platforms was the most significant factor in the company's decision.

3.13.6 COTS Engineering-oriented Class Libraries

Object reuse is often sited as a highly attractive feature of object-oriented development. An additional attractive feature of object-oriented development is that commercially available (COTS) C++ class libraries may be purchased, and of course reused, providing common routines that are often time-consuming to code and offer few Enterprise-unique features. These basic

class libraries may be extended for Enterprise-unique functionality through the intrinsic object-oriented function of inheritance. The following class library, which may not be appropriate or even compatible with ECS development models, is mentioned to illustrate the emergence of commercially available class libraries, even those targeted specifically to an engineering environment. ImageSoft of Port Washington, NY is offering Object/Engineering 3.0, a C++ class library for the scientific and engineering community, which the company claims is portable across Unix, DOS and Windows. The package has three major components: modeling (regressive, digital signal processing, and discrete-event simulation), numerics (random generators, quadratures, functions, differential equations, optimization, sorting, and statistical distributions) and foundations (exception handling, semi-transparent containers, linear algebra, and complex numbers).

4. Related Object Model Topics

4.1 ORB Vendor Alliances

There has been significant amounts of cross-licensing of object and ORB-related technology between individual major vendors, outside of the consortium and standards process. The ability to interoperate across platforms is a strategic necessity for many organizations, including ECS. All environments claiming to be capable of supporting a large Enterprise must provide this type of transparent interoperability. IBM and Sun have licensed HP DOMF technologies. HP and Sun have licensed and are using SOM technologies. IBM and HP have licensed DOE technologies. These major vendors are also committed to ORB and transport interoperability through the OSF (formerly COSE) consortia. The role of Microsoft's OLE and the OpenDoc in relationship to the OMG architecture is the subject of much discussion in industry trade journals. The following provides a brief overview of the relationship of these frequently linked object models.

4.2 Microsoft's OLE (COM) Model

Working with Digital Equipment Company (DEC), Microsoft has recently announced the COM (Common Object Model) architecture, which is based on OLE. As indicated previously, Microsoft is the only major vendor that has not agreed to support the OMG CORBA model. Microsoft has refused requests to submit its OLE (Object Linking and Embedding) architecture for consideration and probable inclusion in the overall OMG model. DEC is supporting Microsoft's Windows NT on several of its hardware platforms. DEC, like Novell, HP, IBM, etc., is basing its future native operating system and development architectures on the OMG CORBA architecture. Without a bridge or translation of some sort, Microsoft's OLE and CORBA objects cannot interoperate. The COM architecture will provide interoperability between Microsoft's OLE and the CORBA platforms that the DEC ObjectBroker. Some CORBA-supporting vendors intend to support the ObjectBroker mechanism, while others have initially refused. IBM has announced the capability of its SOMobjects to interoperate with OLE objects. The IBM SOM object model is like DEC's ObjectBroker based on CORBA and DCE. Sun has also announced its intention to provide a similar interoperability mechanism for the CORBA-compliant DOE environment.

Some consider that OLE is not a complete object model, even at the compound document architecture level. Others maintain that the model is currently not vendor, platform or GUI neutral. A group of vendors concerned with cross-platform interoperability at the compound document architecture level, are supporting an alternate compound document architecture, called OpenDoc. Table 4-1 presents some comparisons of OLE and OpenDoc. OpenDoc is also discussed in the following section.

Microsoft plans to bring OLE to a more complete object model, such as the OMG OMA model, with its more fully object-oriented CAIRO operating system, currently announced to be available in 1995.

Table 4-1. OLE and OpenDoc Comparison

Feature/ Implementation	OLE 2.0	OpenDoc
Vendor Support	Microsoft, many independent software developers	Apple, Borland, IBM, Novell, Oracle, Taligent, Word Perfect, Xerox
Availability	Yes	No Beta on some platforms expected in 3rd quarter 94
Object Model	COM	DSOM (which is CORBA-compliant)
Networkable (over WAN)	No	Yes
Document Storage Formats	DocFiles	Bento
Single-page object-size limitation	Yes	No
OLE interoperability	N/A	Yes
OpenDoc Interoperability	No	N/A
Will submit to OMG Common Facilities	No[7]	Yes

4.3 OpenDoc Compound Document Architecture

Several major Office Automation application vendors, including WordPerfect and Lotus, were able to provide high levels of cross-platform compatibility across their products running on Windows, OS/2, UNIX and often the MAC. OLE was used as the linking and embedding mechanism in the original implementations. OLE is MS-Windows-specific however and could not be supported in most non-MS-Windows-based environments, although OLE is supported by Microsoft on the MAC. This identified the need for an open, cross-platform compound document architecture to many in the vendor community, especially cross-platform software vendors.

To meet this need, the CIL (Component Integration Laboratories) coalition was formed to work on an open, cross-platform, compound document architecture. The architecture was named

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[7] Although OMG has encouraged Microsoft to submit OLE as the Common Facilities Compound Document Architecture, as of this writing, Microsoft has indicated that it will not. Microsoft maintains that third-party-provided gateways or translators, such as DEC's ObjectBroker, will provide CORBA interoperability for the COM (OLE) architecture.

OpenDoc. Apple, IBM, Novell, Oracle, Taligent, WordPerfect, Borland and Xerox are among the members. Lotus has indicated secondary support for OpenDoc, but is proposing its own LEL (Link, Embed and Launch) architecture, which it created to try to solve this problem which was needed for its own distributed applications, especially Notes. Lotus has indicated its intention to make the architecture publicly available. Most of the vendor community concerned about this issue, however, have indicated that an architecture not associated or controlled by a single vendor is a preferred solution. Other third party vendors, such as Symbiotics, a network products developer, are supporting the OpenDoc specifications.

It is intended that OpenDoc be CORBA-compliant, and communicate with OLE. OpenDoc will consists of technologies from the vendors presented in Table 4-2.

Table 4-2. OpenDoc Contributing Vendors

Vendor	Technology
Apple	- Bento object file format - Application integration technology
IBM	- DSOM (Distributed System Object Model)
Novell	- Support for AppWare API - Lower level network services
Word Perfect	- OLE integration with Bento
Borland International	- Application development compilers

The OMG will be considering technologies for a compound document architecture under its Common Facilities Task Force. OpenDoc, LEL, and OLE will be considered if they are submitted to the task force under an RFP process. Microsoft has indicated that it will not submit OLE. The OpenDoc consortium is planning a submission. A high level comparison of OLE 2.0 and IBM's DSOM, which is a principal OpenDoc component is presented below in Table 4-3.

Table 4-3. OLE 2.0 and IBM DSOM High Level Comparison

Provides/ Supports	OLE 2.0	IBM DSOM
Interface Inheritance	Supports aggregations	Multiple Inheritance
Implementation Inheritance	No	Multiple Inheritance
Binary-compatible objects	No	Yes
Objects across WAN Networks	Not currently	Yes

4.4 CORBA 2.0

Responses to the OMG RFP for CORBA 2.0 proposals were due March 7, 1994. Six submissions were made, including those mentioned previously. A review of the proposals is

expected to be completed by July 31, 1994. The specifications will then be published and vendors will make the necessary modifications to bring their products to CORBA 2.0 compliance and interoperate with other CORBA 2.0 implementations.

It is expected that a generalized implementation will be selected, supporting multiple transport mechanisms, including DCE, ONC+ and Novell's IPX. Provisions for gateways are also expected, although gateways could be intrinsic to the inter-ORB communication mechanism. These concepts have been accepted within the industry and should cause no surprise. Interoperable support for DCE, ONC, and IPX was among the earliest COSE commitments and are even more applicable with recent events within both OSF and COSE. DCE is capable of supporting a gateway mechanism for alternate transports; this type of gateway to alternate transports has always been part of the DCE design. It had been the intent of UI (Unix International) before Novell disbanded it, to provide gateways between DCE and ONC+.

If the OMG specifications are close to the joint OSF proposal, HP, DEC (probably IBM, and possibly Novell with HyperDesk DOMS technology) should be able to bring a compliant CORBA 2.0 ORB to market relatively rapidly. If the SunSoft/IONA Orbix proposal is accepted, the IONA Orbix should also be available relatively rapidly. The IONA Orbix ORB is supported on several other platforms, in addition to Sun Solaris, and these should become available within a reasonable period. Most observers believe these are the leading proposals. Even if an outside selection were made, such as the Expersoft XShell submission, this company also supports several platforms and would be available within a period of months.

In addition, because CORBA 2.0 specifications address inter-ORB communications, development done under CORBA 1.1 will not be affected by CORBA 2.0 specifications. The inter-ORB communication mechanism should be transparent at the application level.

4.5 Conclusions

Support for CORBA-compliant object oriented environments will not be restricted to highly specialized environments, but will become mainstream products in the very near future.

Vendors have acknowledged that not only distributed environments must be supported but diverse, heterogeneous, distributed environments must be supported as well. The ORBs, interfaces and toolkits to support this type of environment are currently available on several platforms. Enhancements and new releases are planned. Widely supported, compound document architectures, that are critical to the desktop environment, will also be integrated into the OMG object architecture, with support for existing compound document architectures.

CORBA-compliant ORBs (version 1.1) are available on several platforms from several different vendors. The CORBA development environment, which includes the CORBA IDL and C++ language support, has been specified in version 1.1. There will should be no impact to development done with CORBA 1.1 toolsets, as CORBA 2.0 involves only ORB interoperability mechanisms, such as gateways, which should be transparent to the developed application.

CORBA 2.0-compliant products, which will be needed in the long term, for heterogeneous inter-ORB communication, should emerge from at least one vendor, with support over multiple

platforms, within two months after the publication of the official OMG CORBA 2.0 specifications. Support for additional platforms would be expected over the following six months or so by multiple vendors supporting multiple platforms.

It is nearly a certainty that DCE will be supported by CORBA 2.0. Other transport mechanisms, such as ONC+ and IPX, are also virtually certain to be supported. What is somewhat more uncertain is whether DCE-based ORB implementations will be able to interoperate directly, that is, without the use of a gateway mechanism. CORBA 2.0 may require a gateway mechanism for all inter-ORB communications. Many expect CORBA 2.0 to be transport neutral in regard to major implementations such as DCE, ONC+, IPX (Novell), and Sockets.

The major open systems organizations, including OSF and X/Open, support the current OMG specifications and are expected to support the future OMG standards.

The OMG has published a listing of products which includes the COTS products discussed in this study as well as additional CORBA-compliant COTS products that have not been included in this study. This listing was published with the final release of this paper and could not be incorporated at this time. The additional vendors of CORBA-compliant products include Isis Distributed Systems, NEC Corporation, Lohara Software Systems, NetSmiths Ltd., Object Design, Objectivity, Object Oriented Technologies, Schlumberger Automated Test Equipment, and Silicon Graphics.

ECS will be tracking COTS products supporting this important standard in a continuing effort to provide advanced, commerically available and evolvable solutions within the ECS architecture.